Form Class	Teaching Group	Name and Index Number

PEI HWA SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2021

Secondary Four Express

CHEMISTRY **6092/02**

Paper 2 Theory

25 August 2021

1 hour 45 mins

Additional Materials: NIL

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

1. Write your name, class and index number in the spaces above.
2. There are altogether 2 sections in this paper: Sections **A** and **B**.
3. **Section A: Structured Questions**
   Answer **ALL** questions.
4. **Section B: Free Response Questions**
   Answer **ALL** questions, the last question is in the form either/or.
5. Candidates are to show all their working in a clear and orderly manner.

A copy of the Periodic Table is printed on page 22.

Section		Mark
Paper 1		40
Paper 2	A	50
	B	30
Total		120

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Section A

Answer **all** the questions in the spaces provided.

The total mark for this section is 50.

A1 The letters P, Q, R, S, T, U, V and W show the oxides of some elements.

P	Na_2O
Q	CaO
R	CO
S	Al_2O_3
T	NO
U	PbO
V	SiO_2
W	NO_2

(a) Use the letters P, Q, R, S, T, U, V and W to answer the questions below. The letters can be used once, more than once, or not at all.

(i) Which substance(s) is/are neutral oxides?

..... [1]

(ii) Which substance is added to soil to increase the pH?

..... [1]

(iii) Which substance(s) is/are involved in the reactions in the Blast Furnace?

..... [1]

(iv) Which two substances are used as catalysts in the reaction to convert naphtha into ethene?

..... [1]

(b) Suggest the chemical formula for the compound formed from the reaction between substance U and V.

..... [1]

[Total: 5]

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A2 Hydrogen peroxide is prepared by Merck's process. In this process, hydrogen peroxide is prepared by adding a calculated amount of sodium peroxide to ice-cold dilute sulfuric acid solution, slowly with constant stirring.

The chemical equation for the reaction is as follows:

$$Na_2O_2 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O_2$$

The crystals of sodium sulfate formed upon cooling is removed from hydrogen peroxide, using filtration.

(a) Draw a dot-and-cross diagram, showing only the valence electrons, to illustrate the bonding in hydrogen peroxide.

[2]

(b) Liquid hydrogen peroxide does not conduct electricity.
Explain, with reference to structure and bonding, why this is so.

.....

.....

..... [2]

(c) The common isotopes of the element oxygen are ^{16}O, ^{17}O and ^{18}O.
Table 2.1 shows information about these isotopes of oxygen.

Table 2.1

	oxygen		
isotope	^{16}O	^{17}O	^{18}O
number of protons	8	8	8
number of electrons	8	8	8
number of neutrons	8	9	10
number of electrons in outer shell	6	6	6

(i) Use data from the table to show that ^{16}O, ^{17}O and ^{18}O are isotopes of oxygen.

.....

.....

..... [2]

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(ii) Explain how the data suggests that the three isotopes have the same chemical reactions.

.....

..... [1]

(d) The common isotopes of the element hydrogen are ^{1}H, ^{2}H and ^{3}H.

Determine the highest value of the molecular mass of a hydrogen peroxide molecule.

..... [1]

[Total: 8]

A3 Zinc is an element with the symbol Zn and atomic number 30. It is not a typical transition element.

(a) Suggest two properties of zinc that are not typical of the transition elements.

.....

.....

..... [2]

(b) Zinc salts can be prepared using different methods.

For the following zinc salts, name the starting reagents that can be used and briefly describe how to obtain the solid product from the reaction mixture.

(i) Salt to be prepared: *zinc sulfate*

reagent 1: .....

reagent 2: .....

I could obtain solid zinc sulfate by: .....

.....

(ii) Salt to be prepared: *zinc carbonate*

reagent 1: .....

reagent 2: .....

I could obtain solid zinc carbonate by: .....

..... [4]

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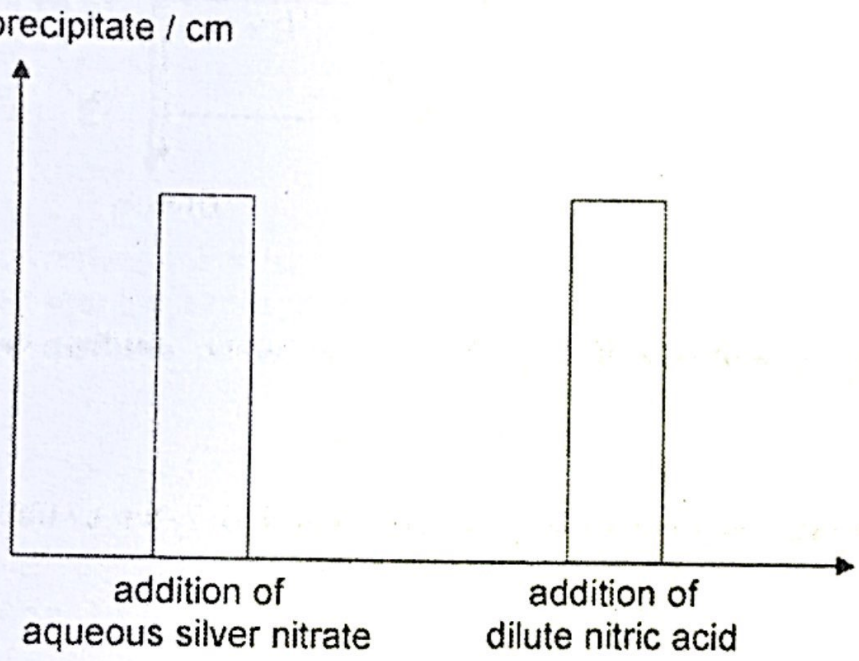
(c) A students spotted a colourless bottle of solution P lying in the lab.
After performing a cation test, it was confirmed that it contains zinc ions.

To identify the anion present, the student performed the following experiment.

1. Add aqueous silver nitrate to solution P.
2. Measure height of precipitate formed after 3 minutes.
3. Then, add dilute nitric acid to the mixture.
4. Measure height of precipitate formed after 3 minutes.

The student presented the results obtained in a graph as shown below.



Deduce the anion present in solution P and explain your deduction with reference to the graph.

.....

.....

..... [2]

[Total: 8]

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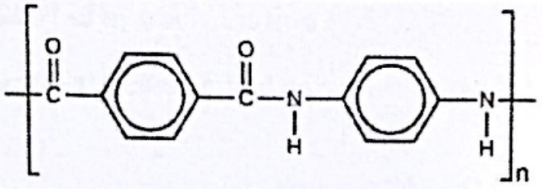
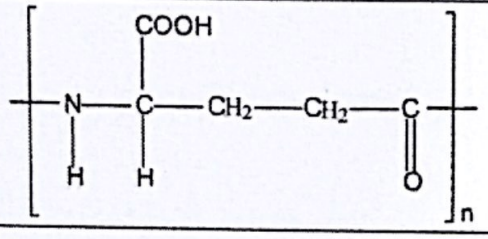
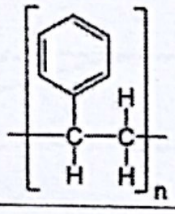
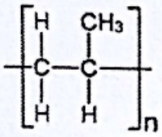
A4 The table shows some information of four polymers, Kevlar, polyglutamic acid, polystyrene and Q.

name of polymer	structure of polymer	uses
Kevlar		bullet-proof vests, helmets
polyglutamic acid		cosmetics such as skin and hair care products
polystyrene		packaging foods and beverages
Q		packaging and labeling, textiles, stationery, plastic parts and reusable containers of various types

(a) State the name of the group that links the monomers together in Kevlar.

.....[1]

(b) State the functional group that is present in a repeat unit of polyglutamic acid.

.....[1]

(c) Name the monomer used to produce polystyrene and draw the structure of polystyrene, showing three repeating units.

[2]

(d) Name Q.

.....[1]

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(e) The polymers shown in the table are made by both addition and condensation polymerization reactions.

Explain **two** differences between these two types of polymerisation.

.....

.....

.....

.....

..... [2]

(f) A sample of Q contains molecules with an average relative molecular mass of 84000.

Determine the number of carbon atoms in an average molecule of the polymer.

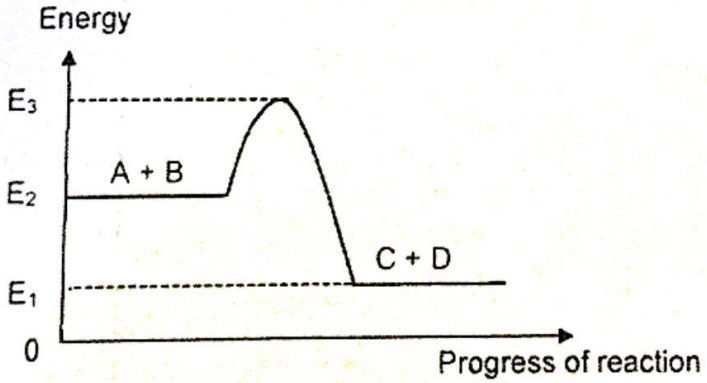
[1]

[Total: 8]

A5 The reaction between A and B to produce C and D is reversible in the following equation.

$$A + B \rightleftharpoons C + D$$

The energy profile diagram below shows the energy changes as the forward reaction proceeds.



(a) What does each of the following energy changes represent?

(i) $E_2 - E_1$: .....

(ii) $E_3 - E_1$: .....

(iii) $E_3 - E_2$: ..... [3]

A6

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(b) Based on the energy profile diagram given, explain whether the forward reaction is exothermic or endothermic.

.....

.....

..... [2]

(c) Heat energy is given out when 500 cm^3 of 1.0 mol/dm^3 sulfuric acid reacts with 200 cm^3 of 2.0 mol/dm^3 aqueous potassium hydroxide.

(i) Write the chemical equation for the above reaction.

..... [1]

(ii) The heat of neutralisation is 57 kJ/mol, which means that the amount of energy released with the formation of 1 mole of water is 57 kJ.

Using this information, calculate the amount of heat released from the above reaction, showing all your workings clearly.

[3]

[Total: 9]

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A6 Oxides of nitrogen and carbon monoxide are emitted from exhaust pipes of vehicles.

(a) (i) Explain how carbon monoxide and oxides of nitrogen are produced in vehicles.

.....

.....

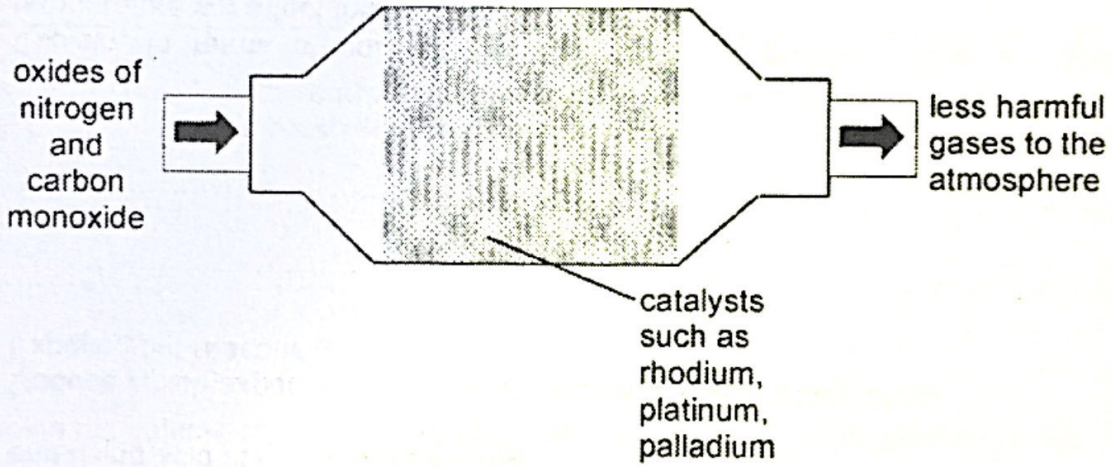
..... [2]

(ii) Describe one harmful effect to the atmosphere if oxides of nitrogen is released to the air.

.....

..... [1]

(b) Catalytic converters minimises carbon monoxide and oxides of nitrogen emissions from vehicles into the atmosphere through redox reaction.



(i) Construct a chemical equation, with state symbols, for the above redox reaction.

..... [1]

(ii) Explain why the conversion is a redox reaction.

.....

..... [1]

[Total: 5]

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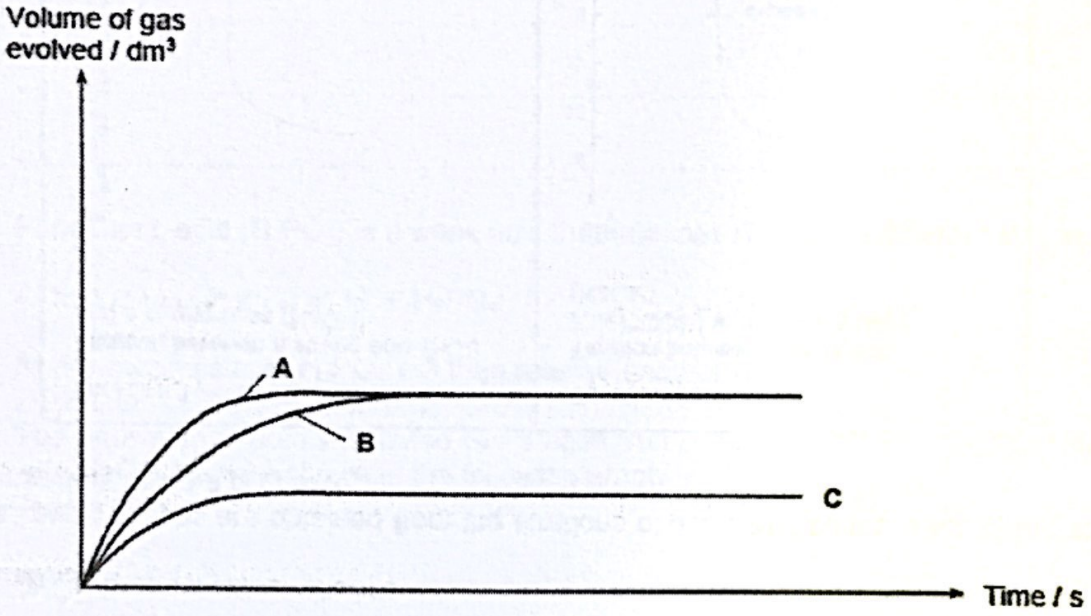
A7 A student wanted to investigate the effect of volume and concentration of hydrochloric acid on the rate of reaction with a piece of magnesium strip.

He started experiment A using 50 cm^3 of 1.0 mol/dm^3 hydrochloric acid to react with excess magnesium metal. Two other experiments, B and C were also carried out, varying only the volumes and concentration of hydrochloric acid.

The graphs of the experiments were plotted as shown below.



(a) Write a balanced chemical equation for the reaction.

..... [1]

(b) With reference to the plotted graphs, suggest the volumes **and** concentrations of hydrochloric acid used in experiments B and C.

Experiment B

concentration: .....

volume: .....

Experiment C

concentration: .....

volume: ..... [2]

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(c) The student also wanted to investigate the effect of temperature on the rate of the same reaction. For this investigation, he used the same volume of hydrochloric acid each time and measured the time taken to collect 10 cm^3 of gas produced at room conditions.

The table shows his results.

experiment	acid	concentration in mol/dm^3	time taken to collect 10 cm^3 of gas
P	hydrochloric	1.0	12
Q	hydrochloric	2.0	5
R	hydrochloric	1.0	7
S	nitric	1.0	12

(i) The student carried out three experiments using acid at room temperature and one using acid at a higher temperature.

Deduce which experiment was carried out at a higher temperature.
Explain your reasoning.

.....

.....

..... [2]

(ii) Explain, in terms of collisions between reacting particles, how a higher temperature will affect the rate of reaction.

.....

.....

..... [2]

[Total: 7]

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Section B

Answer all **three** questions from this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 In a titration experiment, the pH changes are monitored using a pH probe of a data logger.

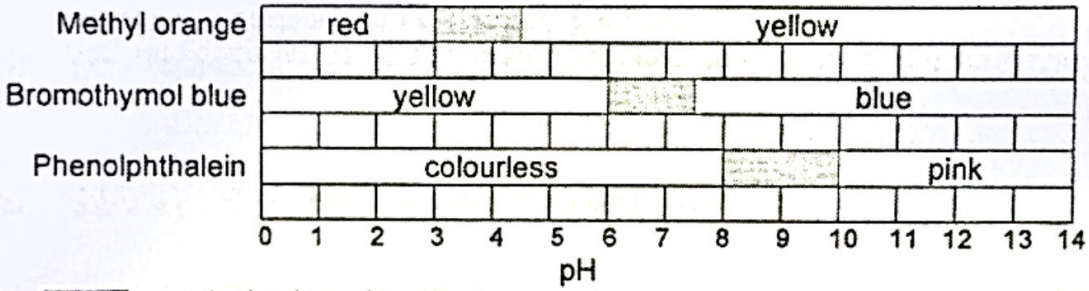
An equivalence point is the point at which the ratio of the number of moles of acid to that of the base is the same as that in a balanced chemical equation.

An indicator is necessary to be used in titration experiments to indicate the point at which the ratio of the number of moles of acid to that of the base is the same as that in a balanced chemical equation, through a distinct colour change.

An endpoint is the point whereby the indicator changes colour during a titration.

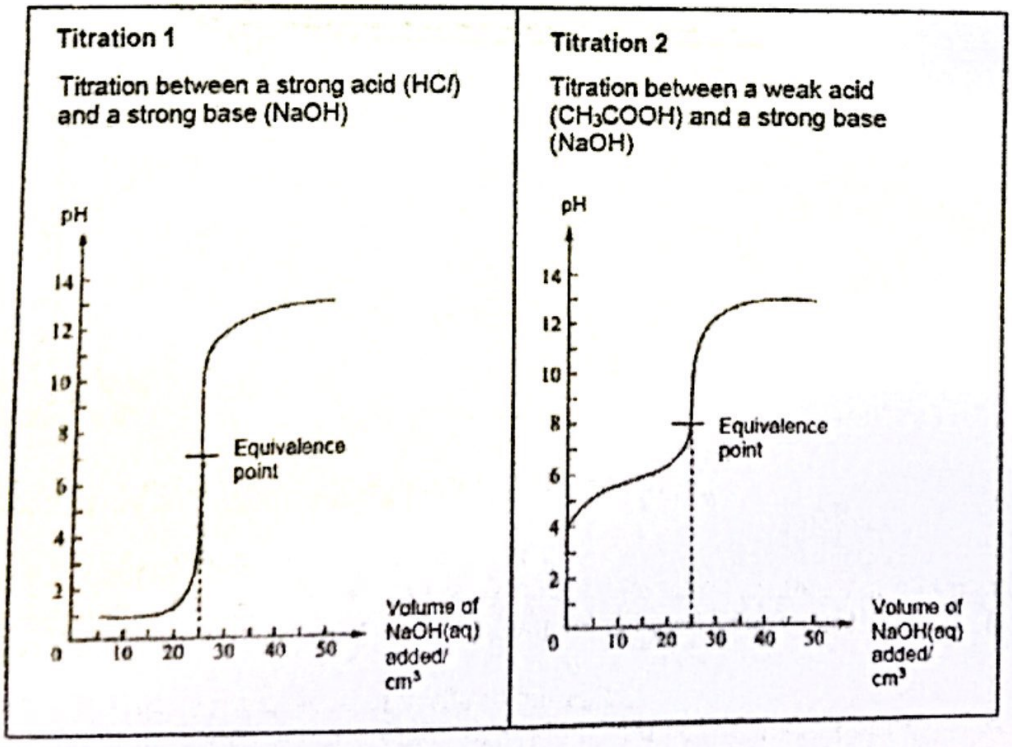
Most indicators change colours gradually over a range of pH values.

The table shows the colours of three indicators at different pH values.



Key: *gradual colour change*

The following graphs are obtained from the titrations of acids and bases, each of the same concentration, using a pH probe.



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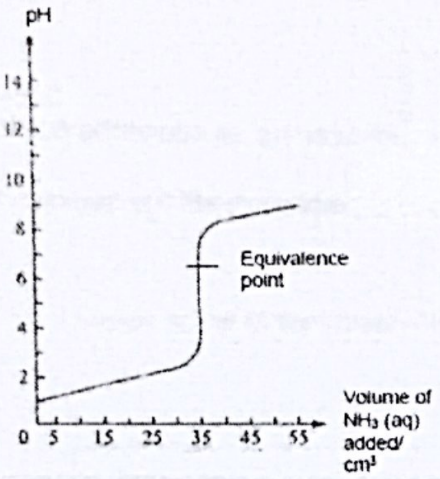
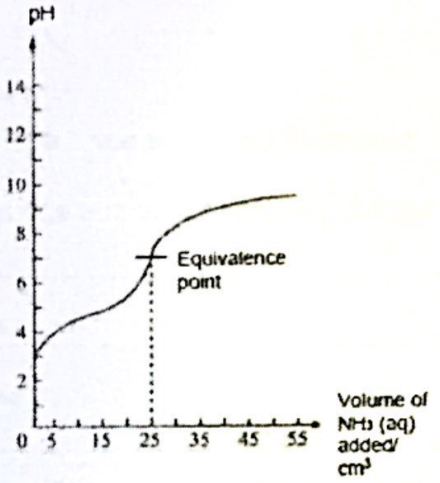
Titration 3

Titration between a strong acid (HCl) and a weak base (aq NH_3)



Titration 4

Titration between a weak acid (CH_3COOH) and a weak base (aq NH_3)



(a) State whether the pH at the equivalence points of all the titrations always coincides with neutral pH. Explain your reasoning from the given information above.

.....

.....

..... [2]

(b) Determine the volume of hydrochloric acid used in Titration 1. Show your workings.

[2]

(c) A good indicator is one that changes colour as close as possible to the equivalence point and hence is suitable for use in the titration.

(i) Explain why methyl orange would not be a suitable indicator to use when titrating ethanoic acid with dilute sodium hydroxide.

.....

..... [1]

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(ii) Suggest the most suitable indicator to use when titrating ethanoic acid with dilute sodium hydroxide.

..... [1]

(d) Ethanoic acid is described as a weak acid but hydrochloric acid is described as a strong acid. Use information from the graphs to explain why.

.....

.....

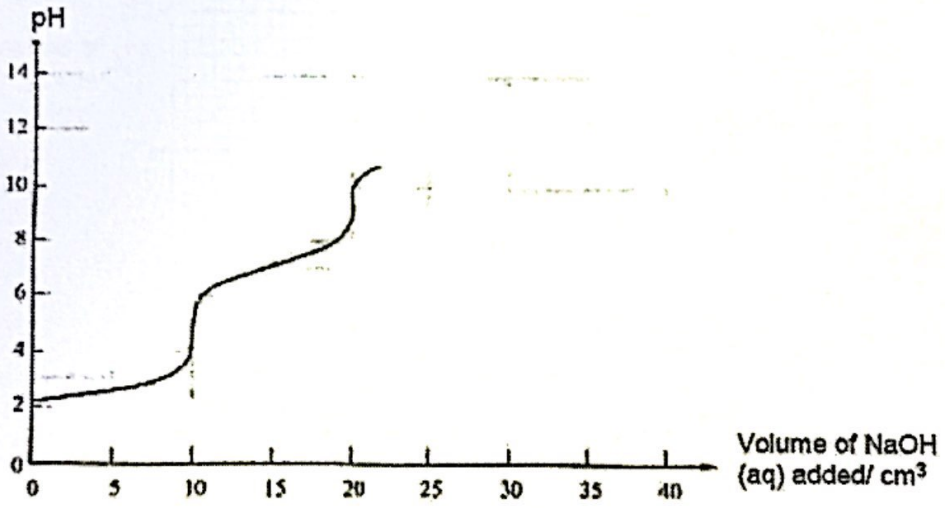
..... [2]

(e) Phosphoric acid (H_3PO_4) is a weak acid that releases H^+ in three different stages.

At first stage: $H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^-$

At the second stage, $H_2PO_4^-$ will then release another H^+ ion.

The equivalence points of these two stages that occur when H_3PO_4 (aq) was titrated with NaOH (aq) are shown in the following graph.



The chemical equation at the first equivalence point is:

$NaOH\ (aq) + H_3PO_4\ (aq) \rightarrow NaH_2PO_4\ (aq) + H_2O\ (l)$

(i) Write the equation to show how phosphoric acid produces the hydrogen ions at the second stage.

..... [1]

(ii) Give the formula for the salt formed at the second stage.

..... [1]

[Total: 10]

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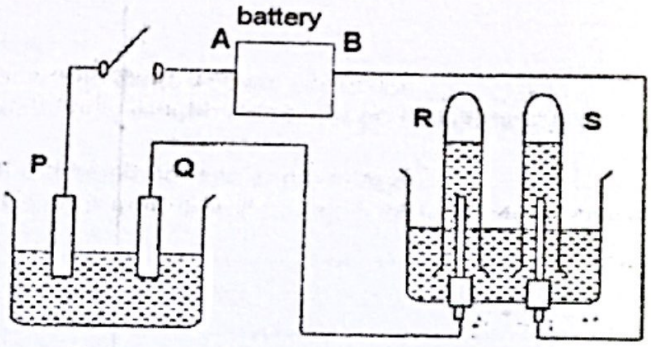
B9 An electric circuit consisting of two electrolytic cells, Cell 1 and Cell 2 are set up as shown below.



Electrodes **P** and **Q** are made of silver while electrodes **R** and **S** are made of carbon.

When the circuit is closed, it is observed that a metal begins to deposit on electrode **Q**.

(a) Deduce the polarity of the battery terminals **A** and **B**.

..... [1]

(b) Write the half equation for the reaction happening in Cell 1 at

electrode **P** .....

electrode **Q** ..... [2]

(c) Describe and explain the colour change of the Universal Indicator during electrolysis of the concentrated sodium chloride solution in Cell 2.

.....

.....

..... [2]

(d) The volumes of gases collected at the cathode and anode in Cell 2 are the same.

By giving equations for the reactions that take place at the two electrodes, explain why this is so.

.....

.....

..... [2]

EITHER

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(e) After half an hour, electrode **Q** is found to gain by a mass of 0.270 g.

Calculate the volume of the gas collected at electrode **R**.

[3]

[Total: 10]

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EITHER

B10(a) A student carried out some experiments to investigate the displacement reactions of four metals namely, copper, cobalt, iron and a metal S. She added the metals separately to various salt solutions.

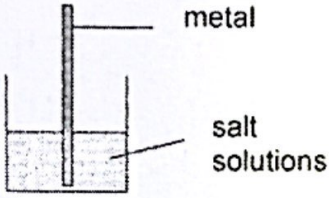

Table 10.1 shows some of the observations she observed.

Table 10.1

	salt solution			
metal	copper(II) sulfate	cobalt(II) sulfate	iron(II) sulfate	sulfate of S
copper			no change, solution remains green	no change, solution remains colourless
cobalt	brown solid forms in pink solution		no change, solution remains green	no change, solution remains colourless
iron	brown solid forms in green solution			no change, solution remains colourless
S	brown solid forms in colourless solution	grey solid forms in colourless solution	grey solid forms in colourless solution	

(i) It was concluded that the order of reactivity of the four metals, in increasing order, is copper, cobalt, iron, S.

Fill in the blanks in Table 10.1 by deducing the observations of the reactions between

(a) copper and cobalt(II) sulfate solution, and

(b) iron and cobalt(II) sulfate solution. [3]

(ii) If metal S was replaced by silver, what will be observed when it is added into copper(II) sulfate solution? Explain your answer.

.....

.....

..... [2]

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10(b) A student compared the rates of reaction of three metal carbonates. She measured the volume of gas released using the apparatus shown below.

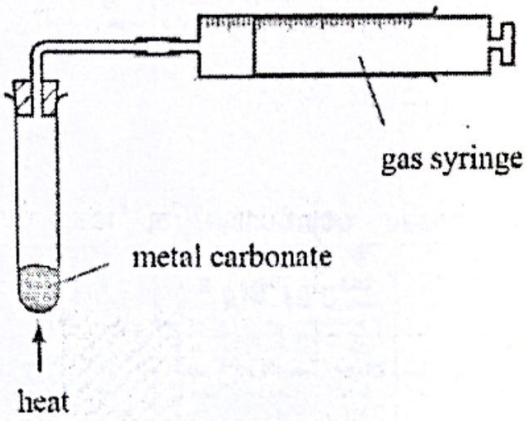

Figure 10.2 shows the volume of carbon dioxide released when the three metal carbonates were heated.

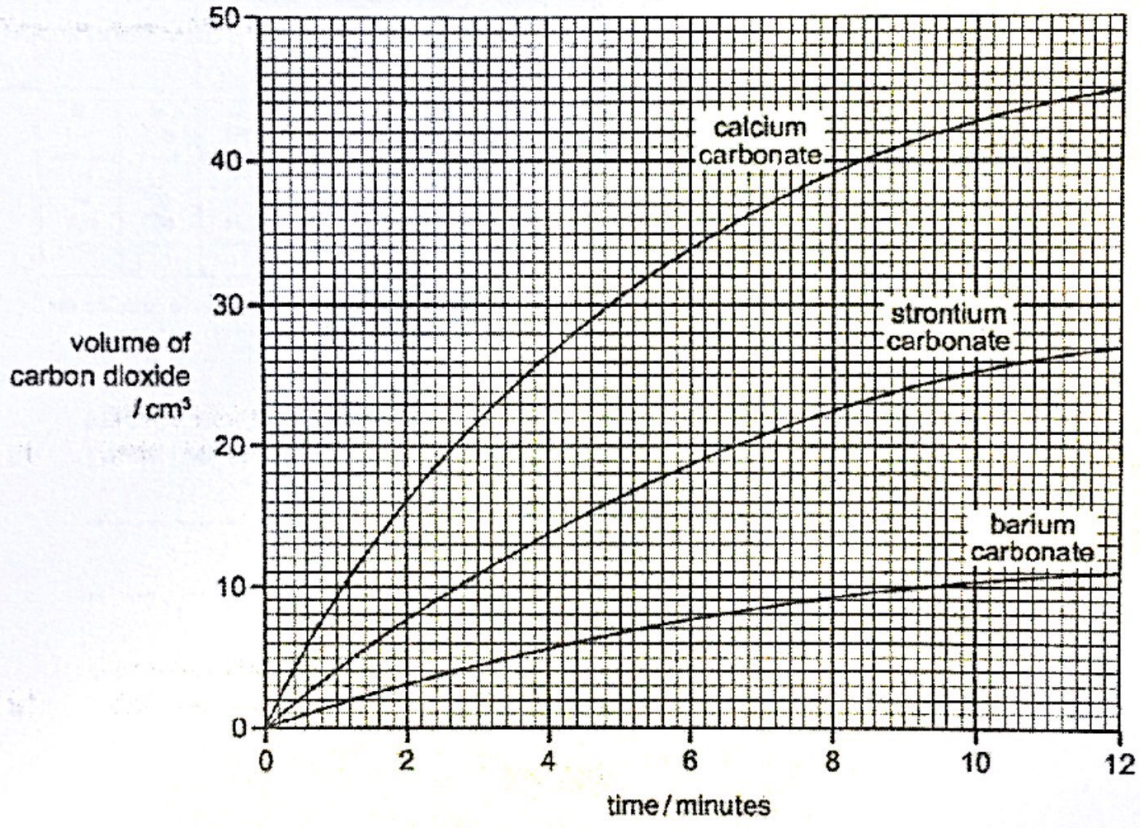

Figure 10.2

(i) State one variable that must be kept constant if the rates of the three reactions are to be compared in a fair way.

..... [1]

(ii) Which carbonate produced carbon dioxide at the highest rate?

..... [1]

(iii) What is the volume of carbon dioxide produced by strontium carbonate in twelve minutes?

..... [1]

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(iv) Explain how the rates of the decomposition of these three metal carbonates relate to the position of calcium, strontium and barium in the Periodic Table?

.....

.....

..... [2]

[Total: 10]

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OR

B10 Perfumes usually contain three classes of compounds called top notes, middle notes and end notes.

(a) Top notes consist of small, light molecules that evaporate quickly.

An example of a top note is styrallyl acetate as shown in Fig. 10.1.

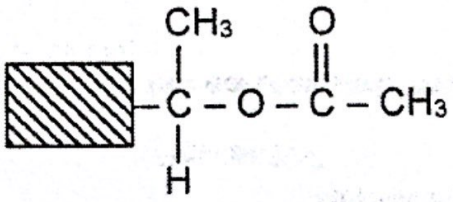

Fig 10.1

(i) With reference to its structure, explain why the compound is likely to have a pleasant smell.

.....

..... [1]

(ii) Draw the structural formulae of the two compounds that are needed to form styrallyl acetate.

[2]

(b) Middle notes vapourise less readily than the top notes.

A typical middle note is 2-phenylethanol. The structure of 2-phenylethanol is as shown in Fig. 10.2.

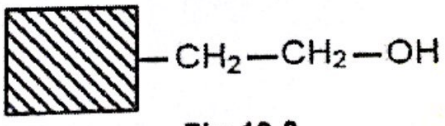

Fig 10.2

Describe a chemical test to distinguish between styrallyl acetate and 2-phenylethanol.

.....

.....

.....

..... [3]

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(c) End notes of a perfume are responsible for the long lasting odour which stays with the user.

The structural formula of a typical end note is as shown in Fig. 10.3.

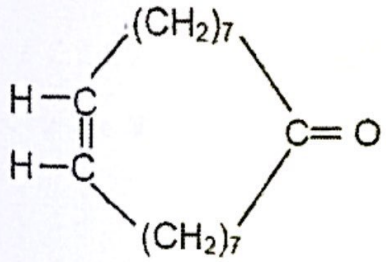

Fig. 10.3

(i) Explain why the end note is an unsaturated compound.

.....

..... [1]

(ii) Draw the structural formula of the product formed when the end note undergoes hydrogenation.

[1]

(iii) Iodine value is a measure of how unsaturated a compound is.

It is the mass, in grams, of iodine that reacts with 100 g of the compound.

Calculate the iodine value for the end note. [Mr of end note is 250]

[2]

[Total: 10]

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DATA SHEET
The Periodic Table of the Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							1 H Hydrogen 1										2 He Helium 4
3 Li Lithium 7	4 Be Beryllium 9											5 B Boron 11	6 C Carbon 12	7 N Nitrogen 14	8 O Oxygen 16	9 F Fluorine 19	10 Ne Neon 20
11 Na Sodium 23	12 Mg Magnesium 24											13 Al Aluminium 27	14 Si Silicon 28	15 P Phosphorus 31	16 S Sulfur 32	17 Cl Chlorine 35.5	18 Ar Argon 40
19 K Potassium 39	20 Ca Calcium 40	21 Sc Scandium 45	22 Ti Titanium 48	23 V Vanadium 51	24 Cr Chromium 52	25 Mn Manganese 55	26 Fe Iron 56	27 Co Cobalt 59	28 Ni Nickel 59	29 Cu Copper 64	30 Zn Zinc 65	31 Ga Gallium 70	32 Ge Germanium 73	33 As Arsenic 75	34 Se Selenium 79	35 Br Bromine 80	36 Kr Krypton 84
37 Rb Rubidium 85	38 Sr Strontium 88	39 Y Yttrium 89	40 Zr Zirconium 91	41 Nb Niobium 93	42 Mo Molybdenum 96	43 Tc Technetium -	44 Ru Ruthenium 101	45 Rh Rhodium 103	46 Pd Palladium 106	47 Ag Silver 108	48 Cd Cadmium 112	49 In Indium 115	50 Sn Tin 119	51 Sb Antimony 122	52 Te Tellurium 128	53 I Iodine 127	54 Xe Xenon 131
55 Cs Caesium 133	56 Ba Barium 137	57 – 71 lanthanoids	72 Hf Hafnium 178	73 Ta Tantalum 181	74 W Tungsten 184	75 Re Rhenium 186	76 Os Osmium 190	77 Ir Iridium 192	78 Pt Platinum 195	79 Au Gold 197	80 Hg Mercury 201	81 Tl Thallium 204	82 Pb Lead 207	83 Bi Bismuth 209	84 Po Polonium -	85 At Astatine -	86 Rn Radon -
87 Fr Francium -	88 Ra Radium -	90 - 103 actinoids	104 Rf Rutherfordium -	105 Db Dubnium -	106 Sg Seaborgium -	107 Bh Bohrium -	108 Hs Hassium -	109 Mt Meitnerium -	110 Ds Darmstadtium -	111 Rg Roentgenium -	112 Cn Copernicium -		114 Fl Flerovium -		116 Lv Livermorium -		

Key: proton (atomic) number; atomic symbol; name; relative atomic mass

lanthanoids	57 La Lanthanum 139	58 Ce Cerium 140	59 Pr Praseodymium 141	60 Nd Neodymium 144	61 Pm Promethium -	62 Sm Samarium 150	63 Eu Europium 152	64 Gd Gadolinium 157	65 Tb Terbium 159	66 Dy Dysprosium 163	67 Ho Holmium 165	68 Er Erbium 167	69 Tm Thulium 169	70 Yb Ytterbium 173	71 Lu Lutetium 175
actinoids	89 Ac Actinium -	90 Th Thorium 232	91 Pa Protactinium 231	92 U Uranium 238	93 Np Neptunium -	94 Pu Plutonium -	95 Am Americium -	96 Cm Curium -	97 Bk Berkelium -	98 Cf Californium -	99 Es Einsteinium -	100 Fm Fermium -	101 Md Mendelevium -	102 No Nobelium -	103 Lr Lawrencium -

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

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